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(54) **COMPUTER INTERCONNECTION SYSTEM**

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G06F 15/16 (2006.01)
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(52) **U.S. Cl.** **709/203**; 709/208; 710/38

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See application file for complete search history.

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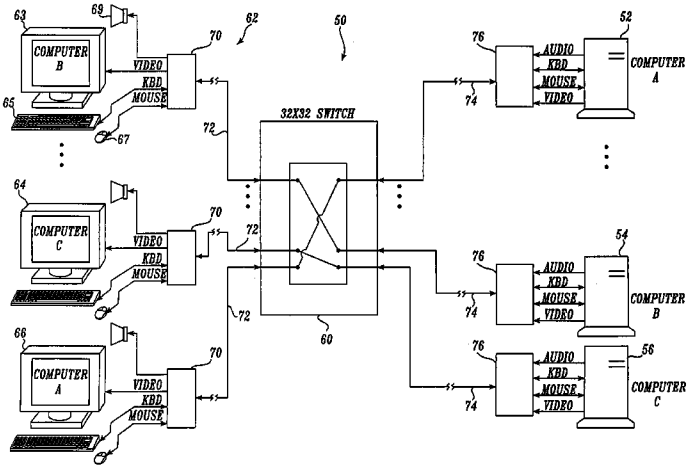
(57) **ABSTRACT**

A computerized switching system for coupling a workstation to a remotely located computer. A signal conditioning unit receives keyboard and mouse signals generated by a workstation and generates a data packet which is transmitted to a central crosspoint switch. The packet is routed through a crosspoint switch to another signal conditioning unit located at a remotely located computer. The second signal conditioning unit applies the keyboard and mouse commands to the keyboard and mouse connectors of the computer as if the keyboard and mouse were directly coupled to the remote computer. Video signals produced by the remote computer are transmitted through the crosspoint switch to the workstation. Horizontal and vertical sync signals are encoded on to the video signals to reduce the number of cables that extend between the workstation and the remote computer. The signal conditioning units connected to the workstations include an onscreen programming circuit that produces menus for the user on a video display of the workstation.

20 Claims, 13 Drawing Sheets



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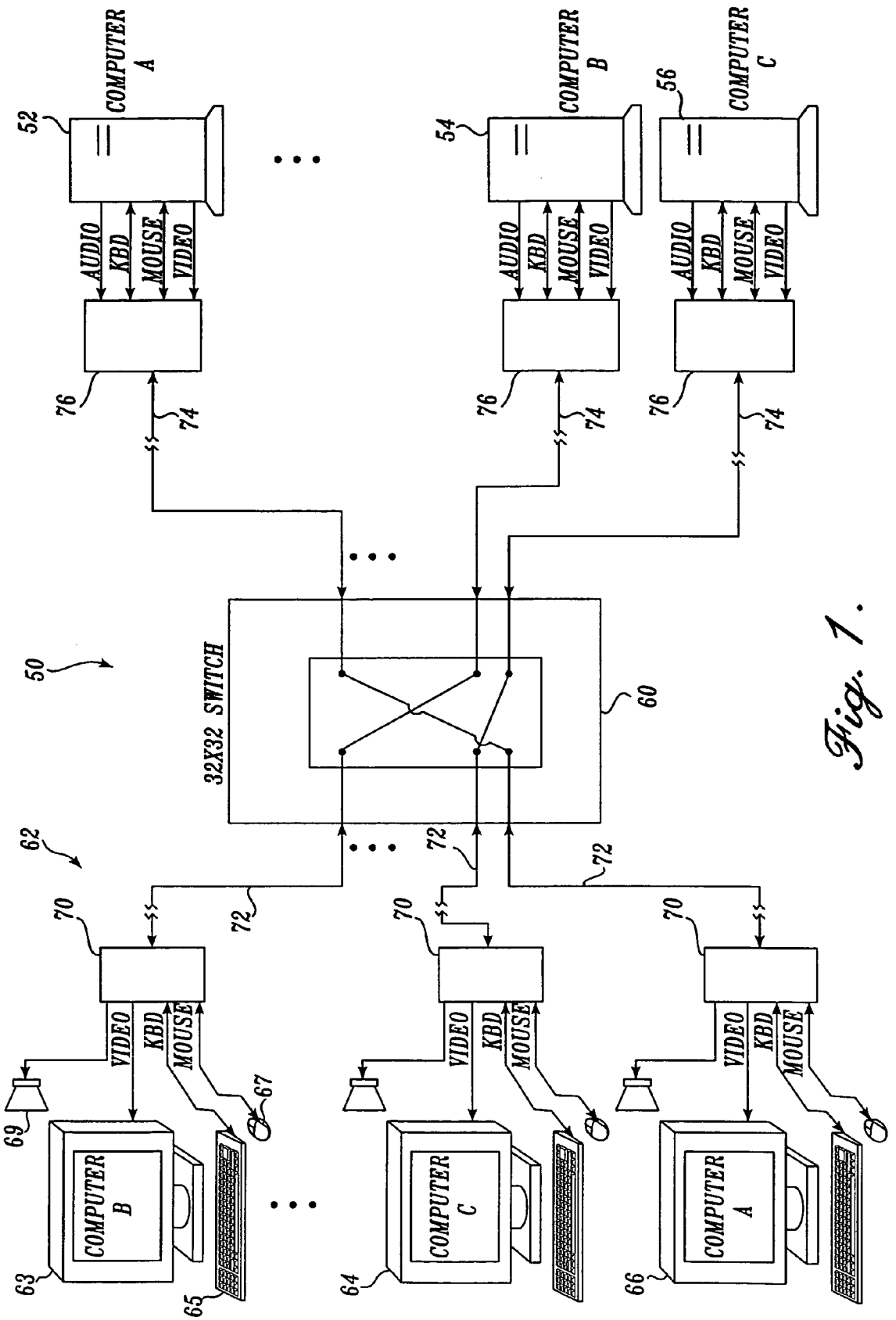

COMPUTER A
COMPUTER B
COMPUTER C
52
54
56
AUDIO
KBD
MOUSE
VIDEO
76
74
50
32X32 SWITCH
60
62
70
72
VIDEO
KBD
MOUSE
67
69
63
65
64
66
COMPUTER B
COMPUTER C
COMPUTER A

Fig. 1.

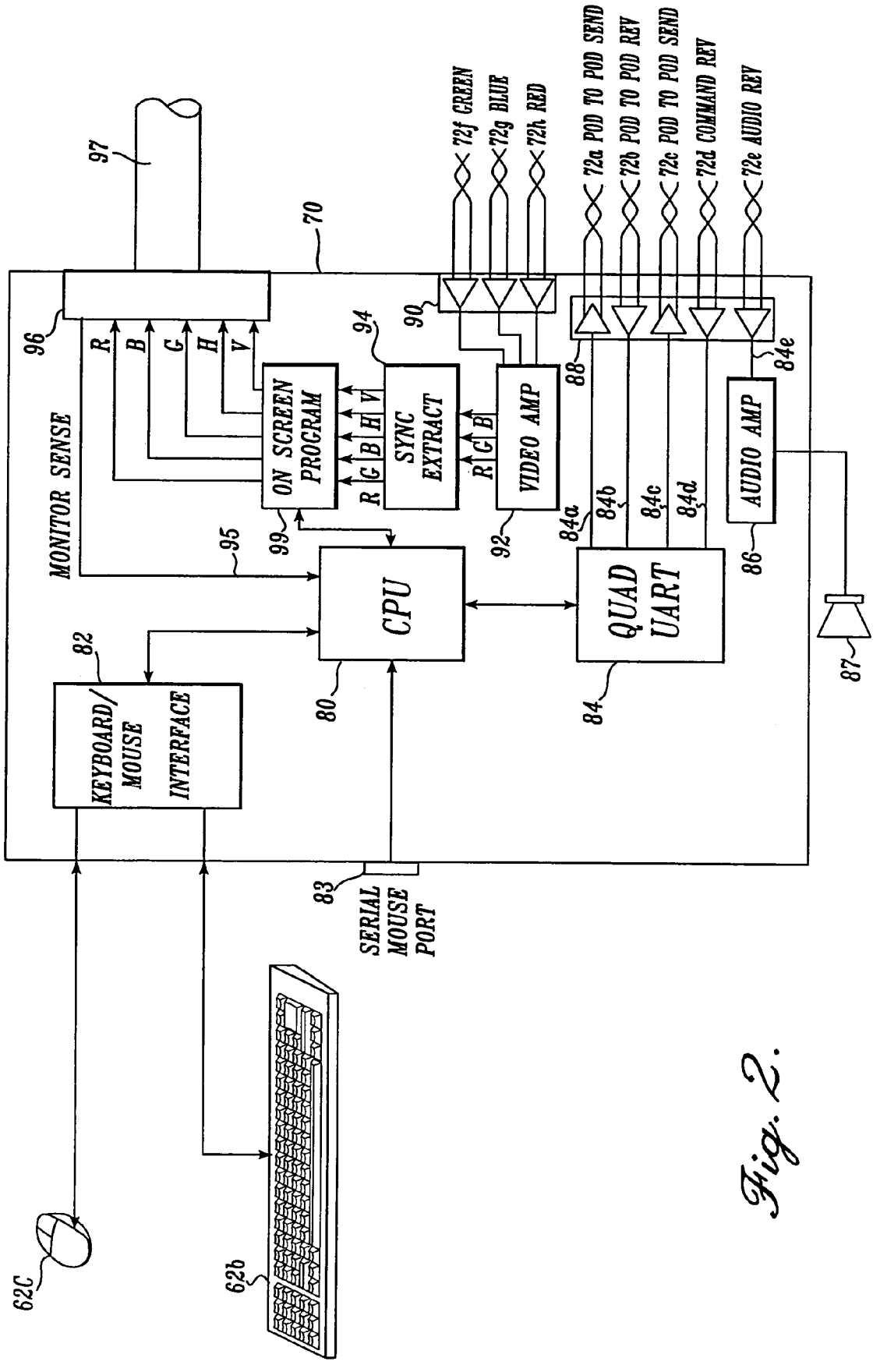

97
70
72f GREEN
72g BLUE
72h RED
72a POD TO POD SEND
72b POD TO POD REV
72c POD TO POD SEND
72d COMMAND REV
72e AUDIO REV
96
90
94
88
84e
R
B
G
H
V
MONITOR SENSE
ON SCREEN PROGRAM
SYNC EXTRACT
VIDEO AMP
AUDIO AMP
95
99
92
84a
84b
84c
84d
86
CPU
QUAD UART
87
82
80
84
KEYBOARD/ MOUSE INTERFACE
83
SERIAL MOUSE PORT
62c
62b

Fig. 2.

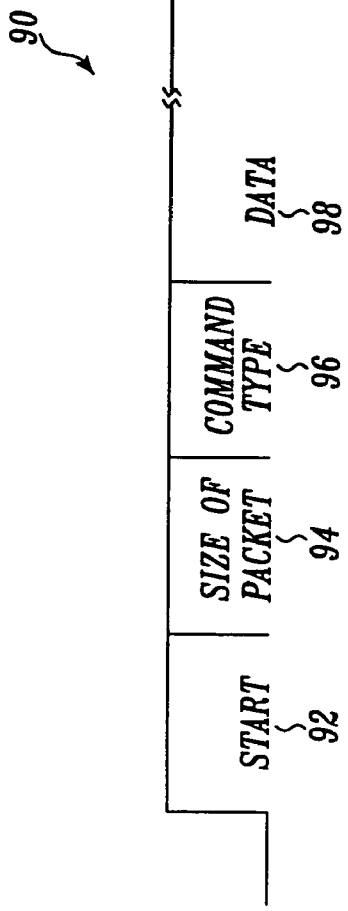

90
START
92
SIZE OF PACKET
94
COMMAND TYPE
96
DATA
98
CHECK SUM
100

Fig. 2A.

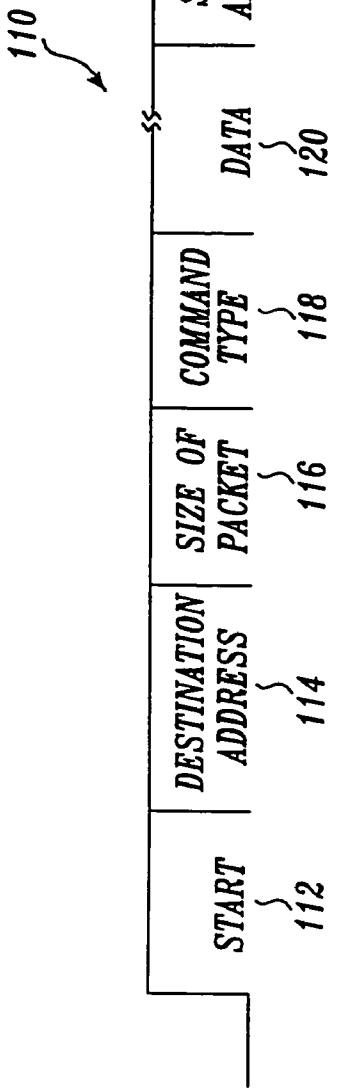

110
START
112
DESTINATION ADDRESS
114
SIZE OF PACKET
116
COMMAND TYPE
118
DATA
120
SENDER ADDRESS
122
CHECK SUM
124
TRAILER
126

Fig. 2B.

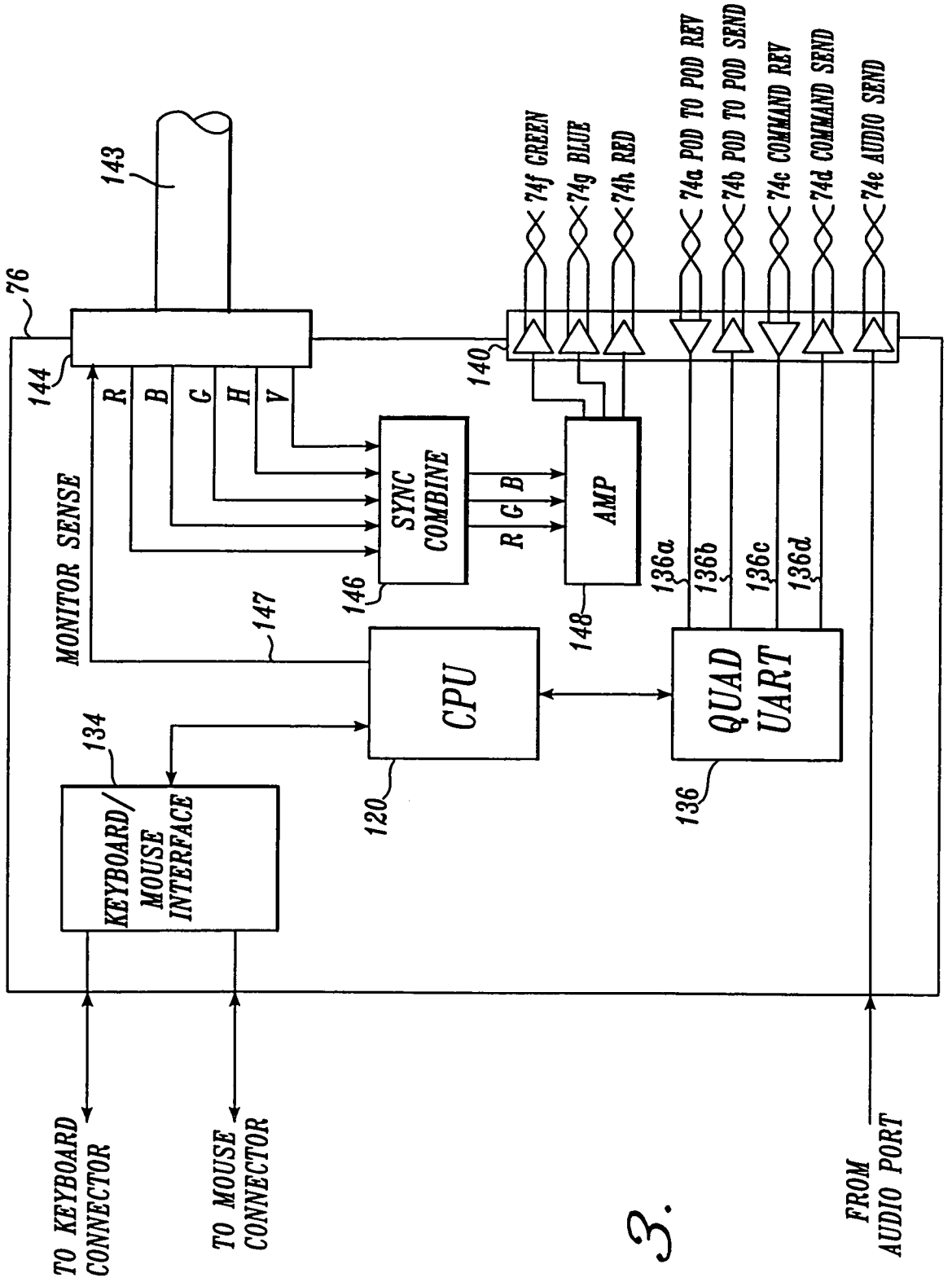

143
76
144
R
B
G
H
V
MONITOR SENSE
147
SYNC COMBINE
146
R G B
AMP
148
140
74f GREEN
74g BLUE
74h RED
74a POD TO POD REV
74b POD TO POD SEND
74c COMMAND REV
74d COMMAND SEND
74e AUDIO SEND
136a
136b
136c
136d
CPU
120
QUAD UART
136
134
KEYBOARD/ MOUSE INTERFACE
TO KEYBOARD CONNECTOR
TO MOUSE CONNECTOR
FROM AUDIO PORT

Fig. 3.

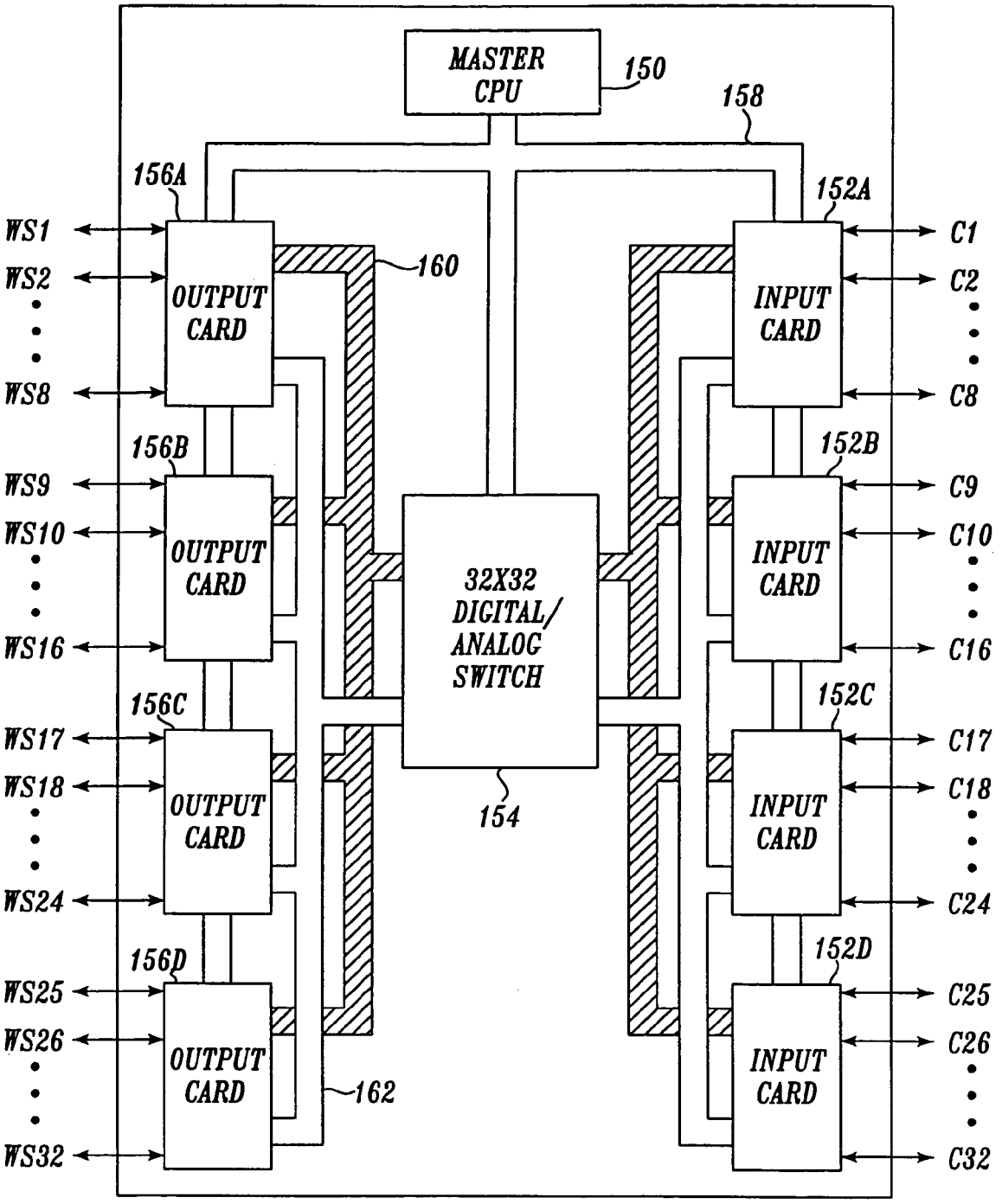

MASTER CPU
150
158
156A
152A
WS1
WS2
WS8
OUTPUT CARD
160
INPUT CARD
C1
C2
C8
156B
152B
WS9
WS10
WS16
OUTPUT CARD
32X32 DIGITAL/ ANALOG SWITCH
INPUT CARD
C9
C10
C16
156C
152C
WS17
WS18
WS24
OUTPUT CARD
154
INPUT CARD
C17
C18
C24
156D
152D
WS25
WS26
WS32
OUTPUT CARD
162
INPUT CARD
C25
C26
C32

Fig. 4.

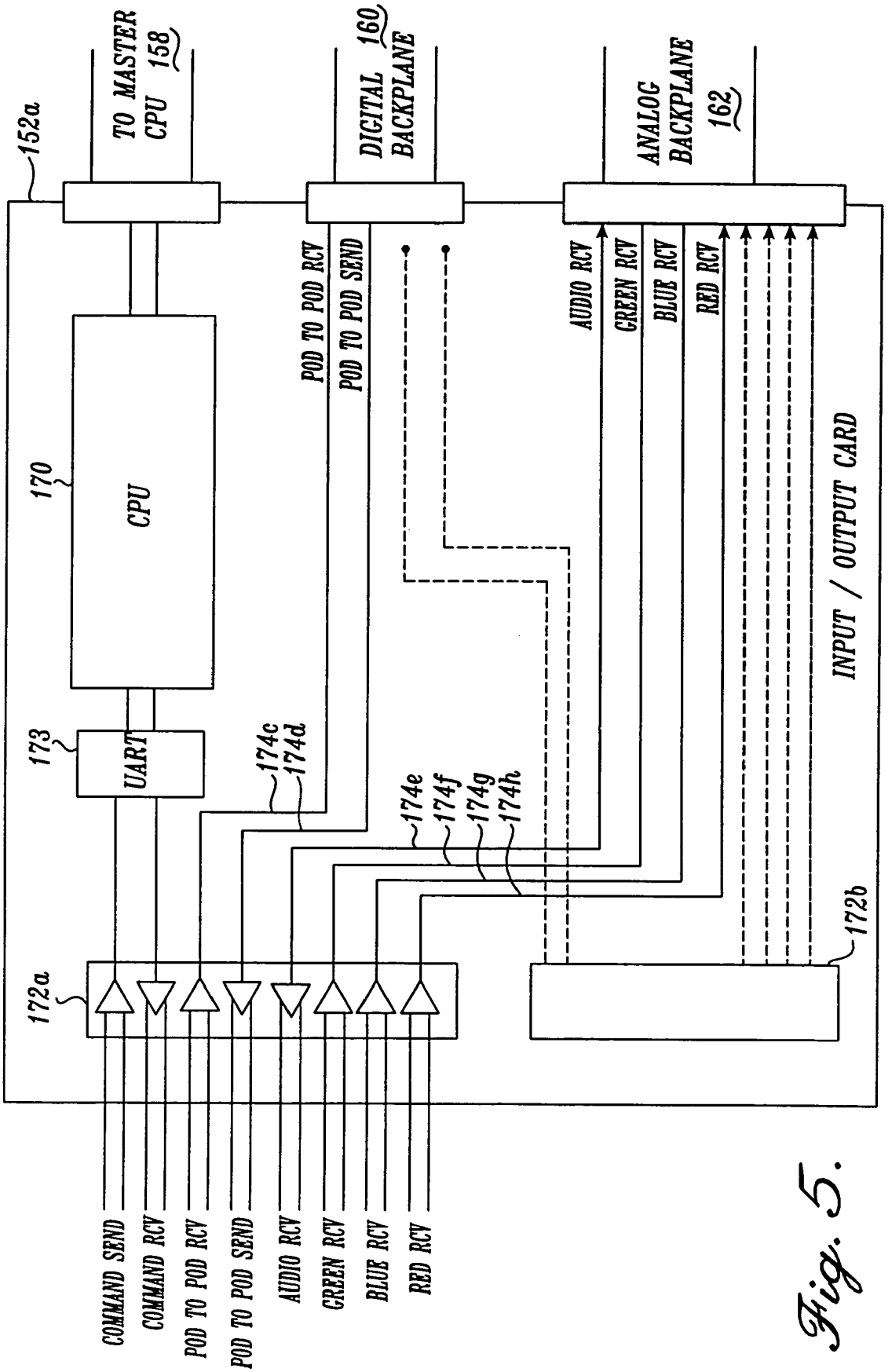

152a
TO MASTER CPU 158
DIGITAL BACKPLANE 160
ANALOG BACKPLANE 162
170
CPU
173
UART
POD TO POD RCV
POD TO POD SEND
AUDIO RCV
GREEN RCV
BLUE RCV
RED RCV
174c
174d
174e
174f
174g
174h
172a
172b
INPUT / OUTPUT CARD
COMMAND SEND
COMMAND RCV
POD TO POD RCV
POD TO POD SEND
AUDIO RCV
GREEN RCV
BLUE RCV
RED RCV

Fig. 5.

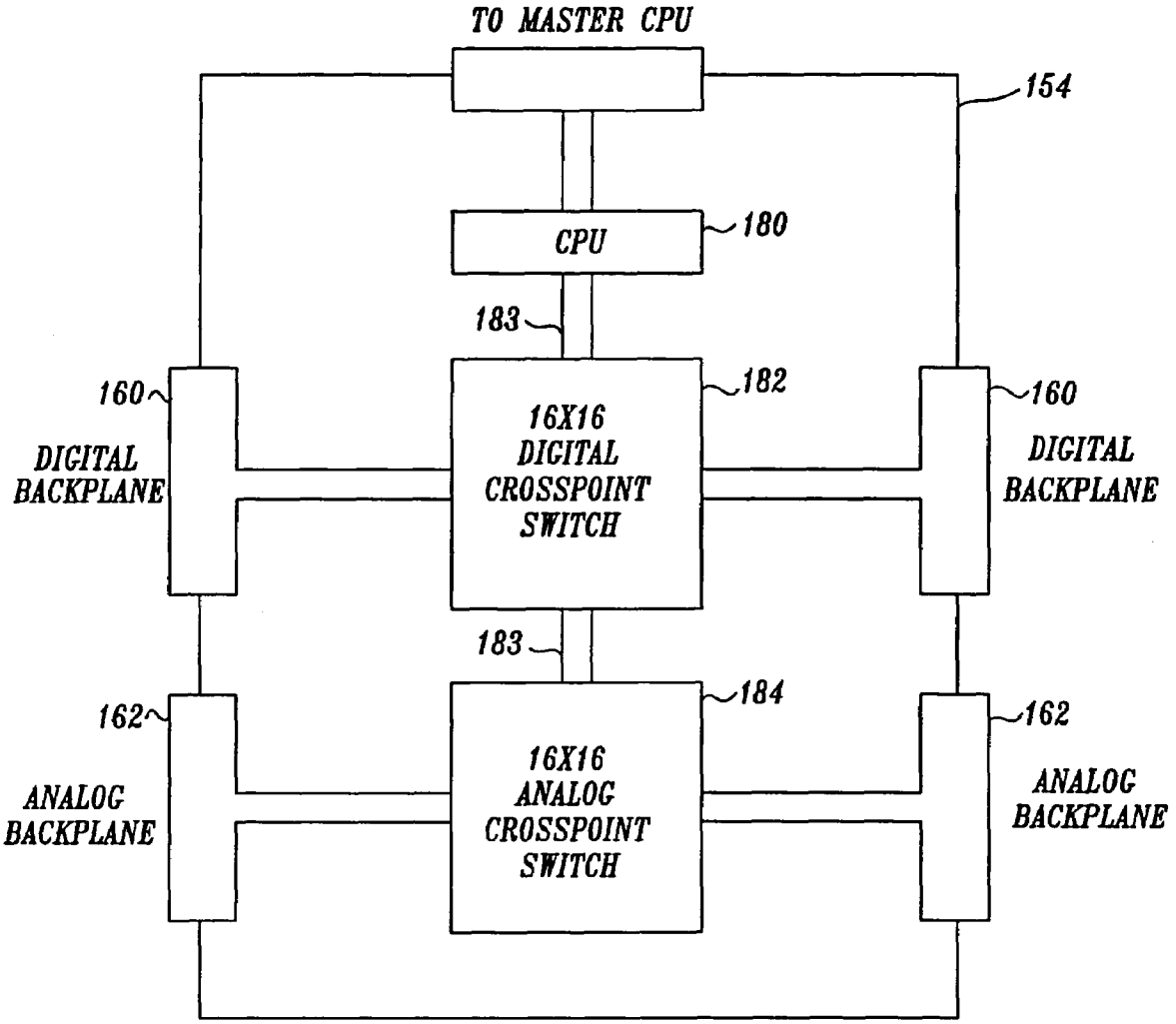

TO MASTER CPU
154
CPU
180
183
160
DIGITAL BACKPLANE
182
16X16 DIGITAL CROSSPOINT SWITCH
160
DIGITAL BACKPLANE
183
184
162
ANALOG BACKPLANE
16X16 ANALOG CROSSPOINT SWITCH
162
ANALOG BACKPLANE

Fig. 6.

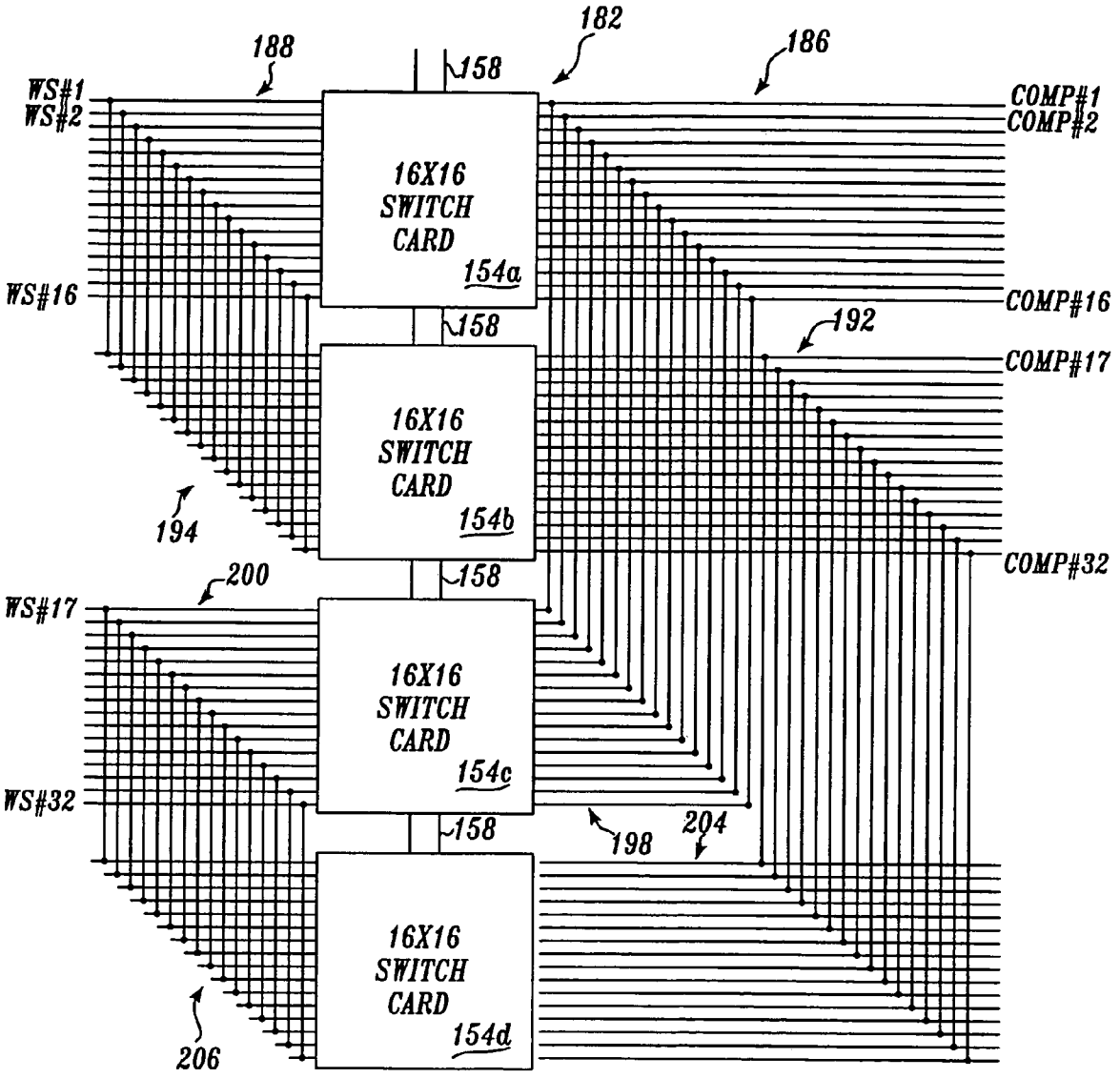

188
182
186
158
WS#1
WS#2
COMP#1
COMP#2
16X16
SWITCH
CARD
154a
WS#16
COMP#16
158
192
COMP#17
16X16
SWITCH
CARD
154b
194
200
158
COMP#32
WS#17
16X16
SWITCH
CARD
154c
WS#32
158
198
204
16X16
SWITCH
CARD
154d
206

Fig. 7.

Fig. 8.

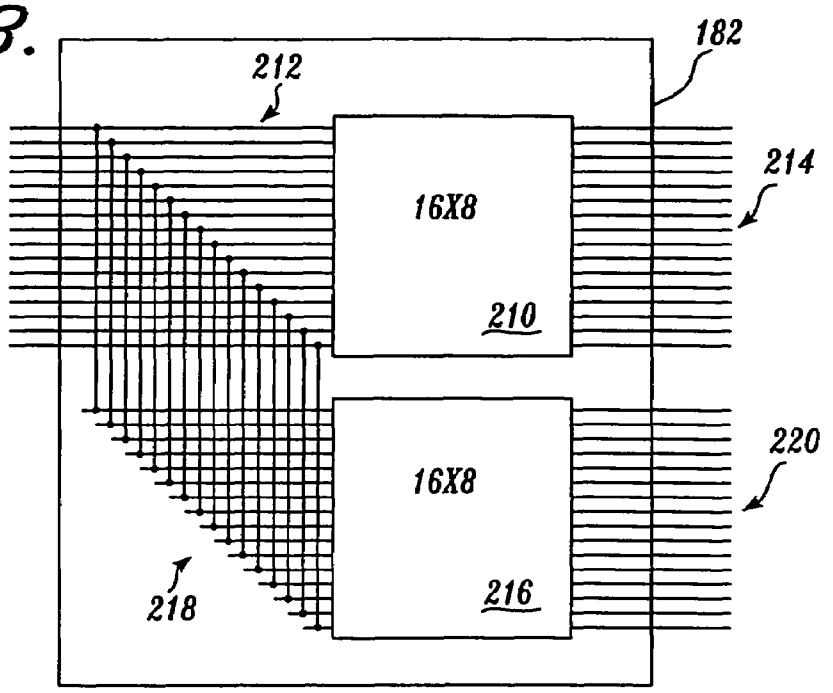
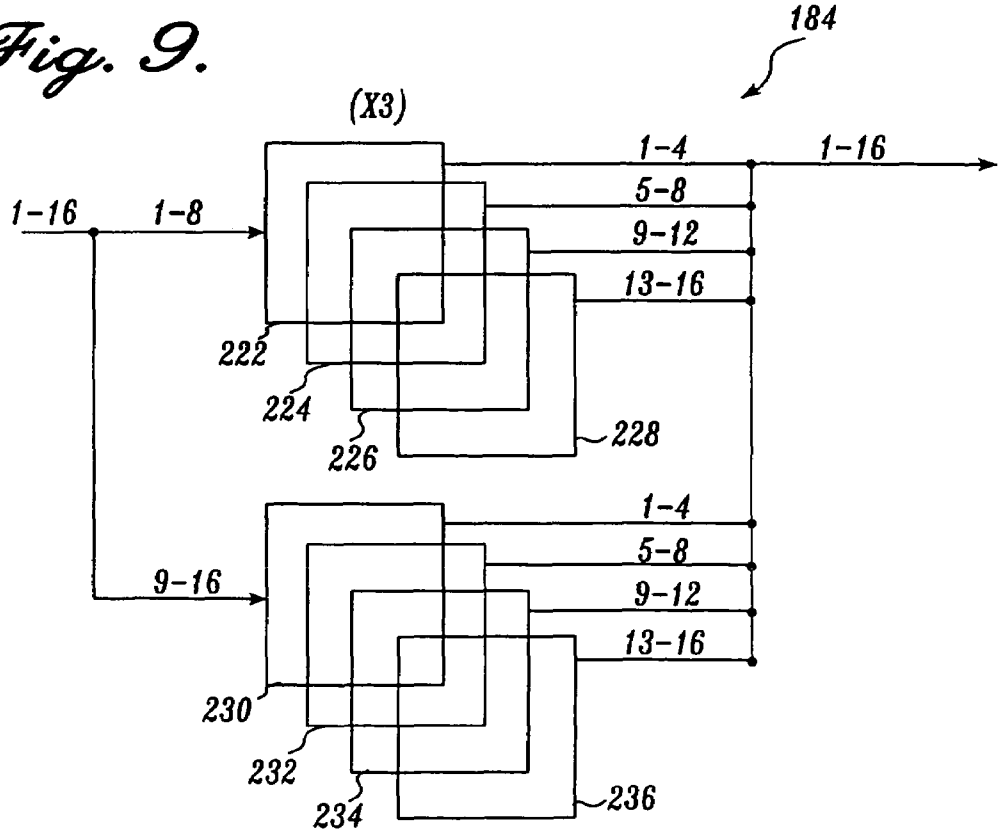


Fig. 9.



THE VIDEO BUS USES 8 8X4 SWITCHES PER COLOR.
TOTAL VIDEO SWITCHES EQUALS 24.

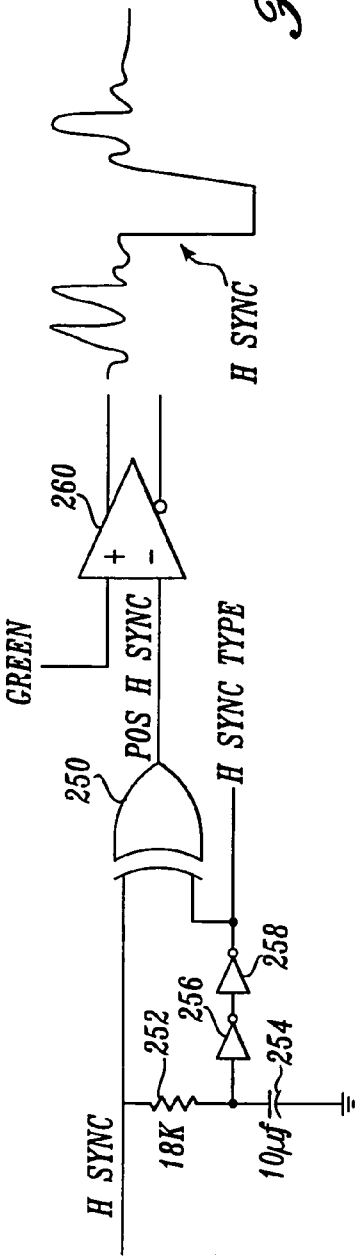


Fig. 10A.

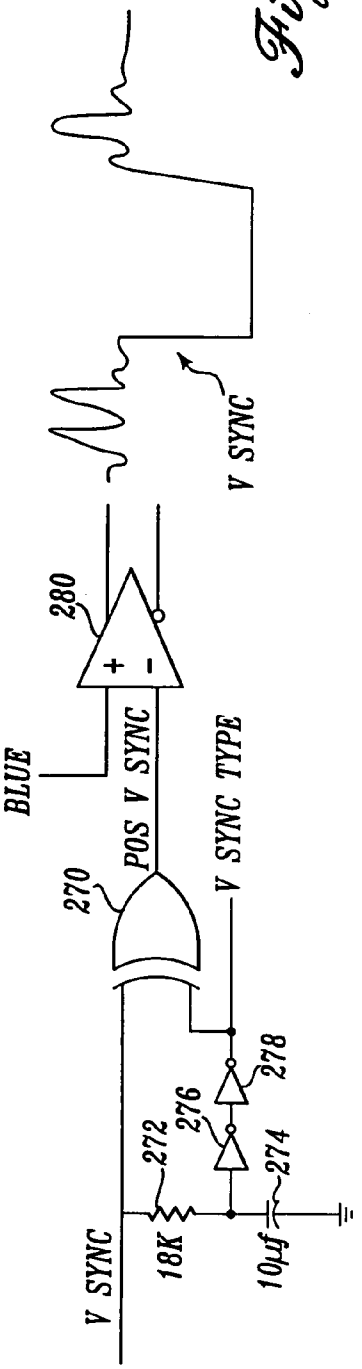


Fig. 10B.

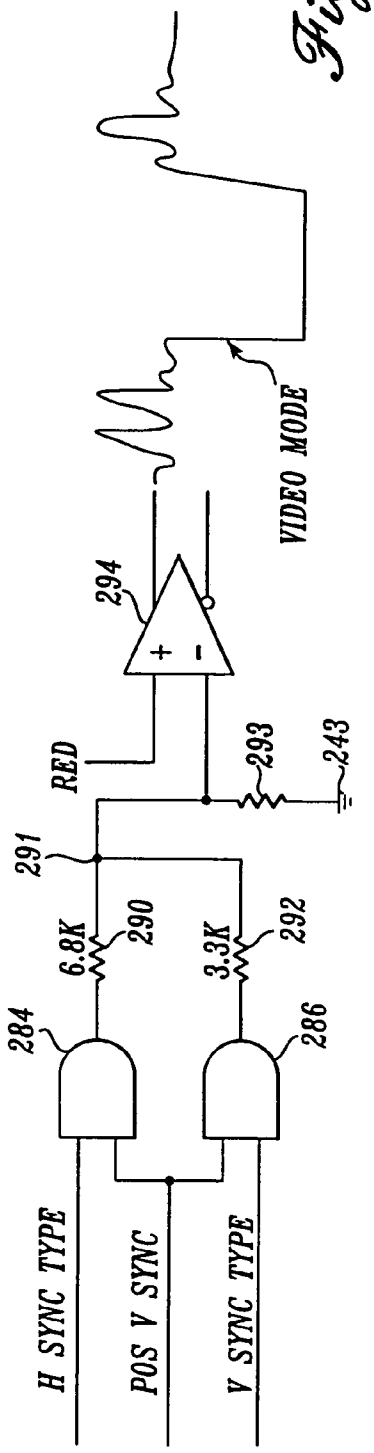


Fig. 10C.

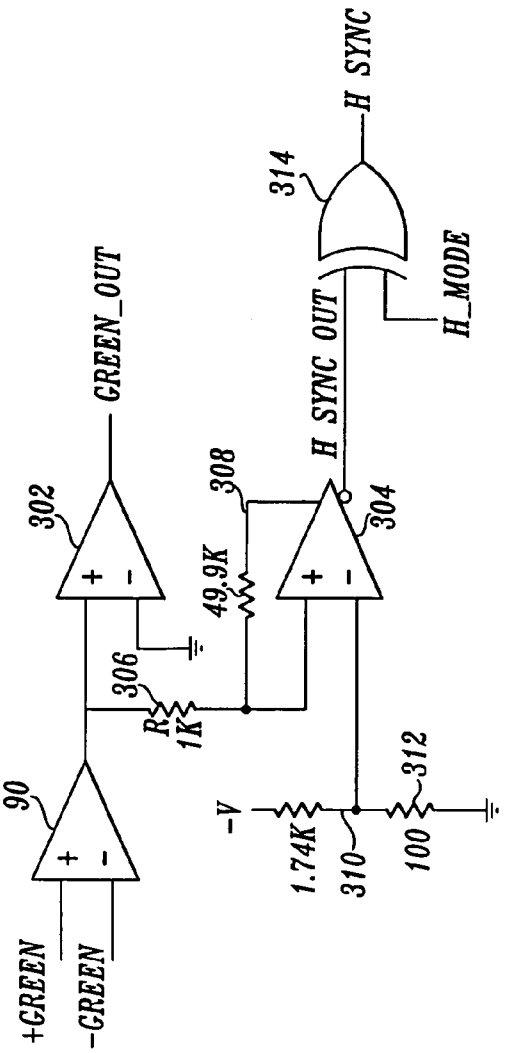


Fig. 11A.

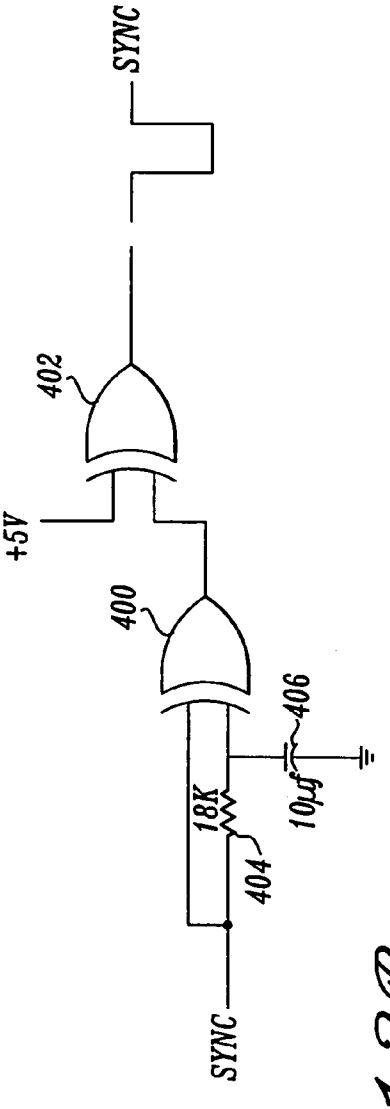


Fig. 12B.

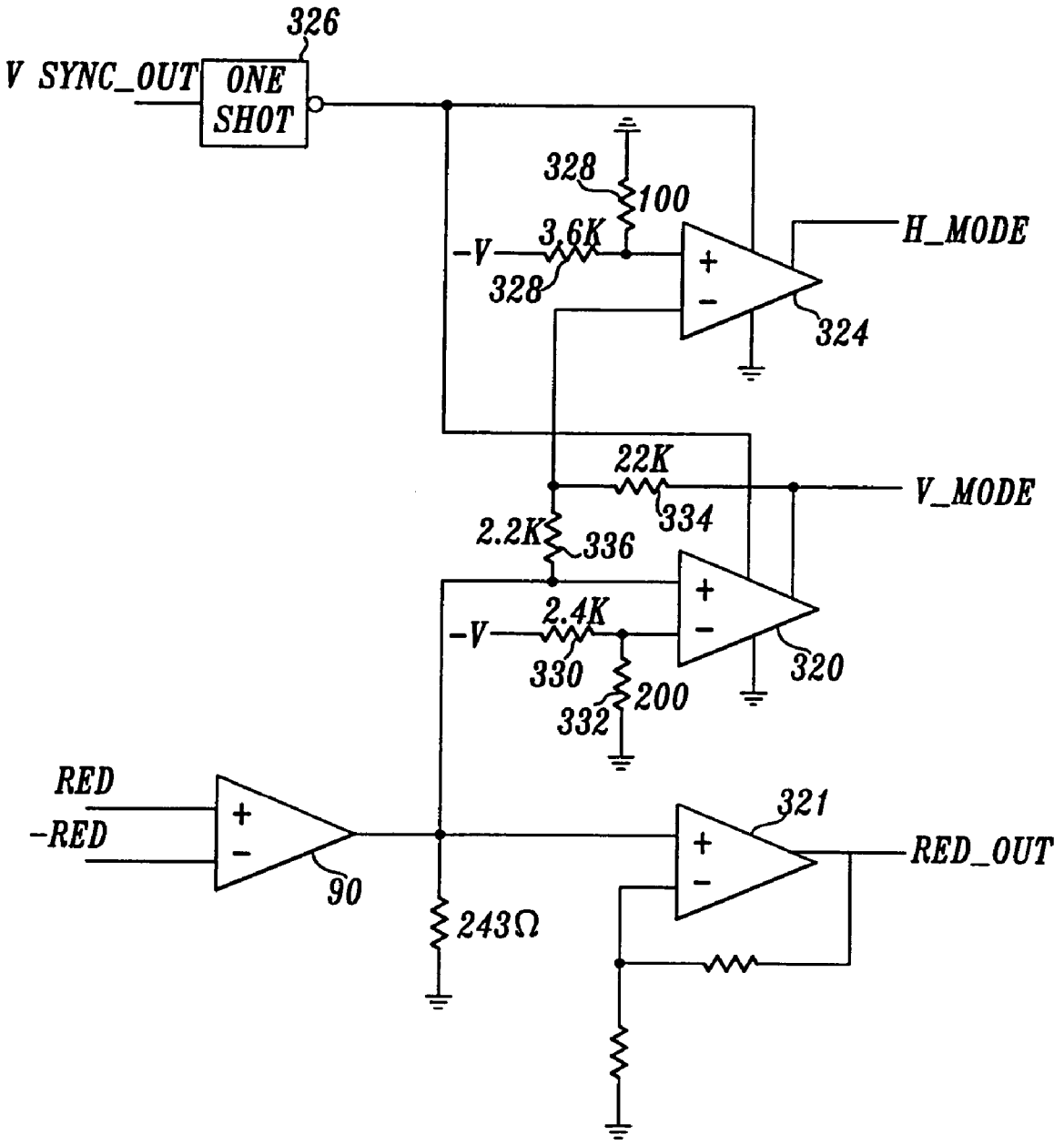

326
V SYNC_OUT
ONE SHOT
328
100
3.6K
-V
328
H_MODE
324
22K
V_MODE
334
2.2K
336
2.4K
-V
330
320
200
332
RED
-RED
90
321
RED_OUT
243Ω

Fig. 11B.

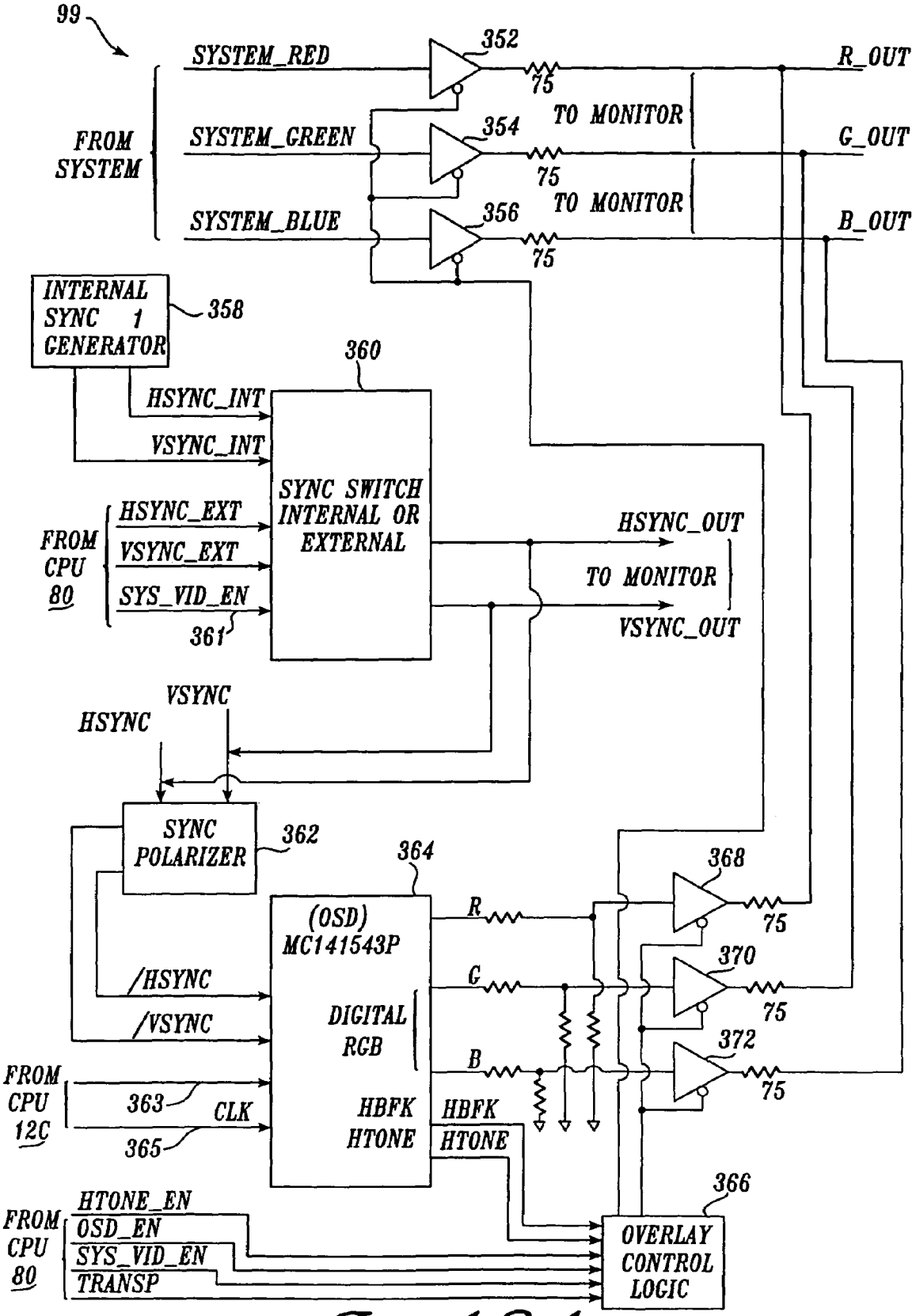

99
SYSTEM_RED
352
R_OUT
75
TO MONITOR
FROM SYSTEM
SYSTEM_GREEN
354
G_OUT
75
TO MONITOR
SYSTEM_BLUE
356
B_OUT
75
INTERNAL SYNC 1 GENERATOR
358
360
HSYNC_INT
VSYNC_INT
SYNC SWITCH INTERNAL OR EXTERNAL
FROM CPU 80
HSYNC_EXT
VSYNC_EXT
SYS_VID_EN
361
HSYNC_OUT
TO MONITOR
VSYNC_OUT
VSYNC
HSYNC
SYNC POLARIZER
362
364
(OSD) MC141543P
368
370
372
R
G
B
75
/HSYNC
/VSYNC
DIGITAL RGB
FROM CPU 12C
363
CLK
365
HBFK
HTONE
366
HTONE_EN
FROM CPU 80
OSD_EN
SYS_VID_EN
TRANSP
OVERLAY CONTROL LOGIC

Fig. 12A.

COMPUTER INTERCONNECTION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 09/683,582 filed on Jan. 22, 2002, which is a continuation of U.S. patent application Ser. No. 09/590,170 filed on Jun. 9, 2000, now U.S. Pat. No. 6,345,323, which is a continuation of U.S. patent application Ser. No. 09/244,947 filed on Feb. 4, 1999, now U.S. Pat. No. 6,112,264, which is a continuation of U.S. patent application Ser. No. 08/969,723 filed on Nov. 12, 1997, now U.S. Pat. No. 5,884,096, which is a continuation of U.S. patent application Ser. No. 08/519,193 filed on Aug. 25, 1995, now U.S. Pat. No. 5,721,842. The contents of all of these applications are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to systems for interconnecting remotely located computers.

BACKGROUND OF THE INVENTION

In a typical local computer network there are a number of client computers that are coupled via a communication link to a number of network server resources. These resources include file servers, print servers, modem servers, and CD-ROM servers for example. Each server is usually a stand alone computer with its own keyboard, mouse and video monitor. Each client computer can utilize the functions provided by the server computers through the communication link.

Most computer networks have one or more system administrators, i.e. human operators, for the server computers. The system administrators monitor the operation of the software running on the server computers, load new software packages, delete outdated files and perform other tasks necessary to maintain the operation of the network. While most administrator tasks (modifying software, deleting files, etc.) can be performed over the network from a client computer, there are some situations where the network administrators must be physically located at the server computers for direct access to and operation of them. For example, it is not possible to reboot a server computer over the network. If the server computers are not close together, the time required for a task as simple as rebooting can be substantial.

Although it is possible to run dedicated communication links to each server computer in order to allow a system administrator to operate the network from a central location, a large number of cables are required for anything other than a very simple network.

SUMMARY OF THE INVENTION

The present invention provides a computerized switching system that allows centrally located network administrators to operate multiple server computers over long distances without requiring a complicated wiring scheme. In general, the switching system allows data transmission between a workstation and a remotely located server computer. A signal conditioning unit receives keyboard and mouse signals from a workstation and generates a serial data packet which is transmitted to a central crosspoint switch. The crosspoint switch routes the keyboard/mouse packet to another signal conditioning unit that is coupled to the remotely located server computer. The signal conditioning unit coupled to the server computer decodes the keyboard/mouse packet and applies the signals to a keyboard and mouse connector on the remote computer in the same manner as if the mouse and keyboard were directly coupled to the remote computer.

Video signals produced by the remote computer are transmitted through the crosspoint switch to the workstation. In order to minimize the number of wires extending between the remote computer and the workstation, the horizontal and vertical sync signals as well as a mode signal are encoded with the analog video signals. The present embodiment of the invention allows any of thirty-two workstations to be connected to any of thirty-two remotely located server computers.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a pictorial diagram of a computerized switching system, according to the present invention, a number of workstations and a number of remotely-located computers;

FIG. **2** is a block diagram of a signal conditioning unit (pod) that is coupled to a workstation;

FIG. **2**A is a timing diagram of a serial pod to pod packet that is transmitted by the signal conditioning unit shown in FIG. **2**;

FIG. **2**B is a timing diagram of a data packet that is routed within the central crosspoint switch;

FIG. **3** is a block diagram of a signal conditioning unit (pod) that is coupled to a remote computer system;

FIG. **4** is a block diagram of a crosspoint switch according to the present invention that routes data between a workstation and a remote server computer;

FIG. **5** is a block diagram of an input/output card that is utilized to send and receive signals at the crosspoint switch;

FIG. **6** is a block diagram of a switch card that routes signals through the crosspoint switch;

FIG. **7** is a schematic diagram showing the interconnection of four switch cards to create a 32×32 switch utilized in the crosspoint switch of the present invention;

FIGS. **8** and **9** are schematic diagrams showing how a digital and analog 16×16 switch is constructed;

FIGS. **10**A-**10**C are schematic diagrams of circuits for encoding horizontal sync, vertical sync and video mode signals onto an analog video signal according to another aspect of the present invention;

FIGS. **11**A and **11**B are schematic diagrams of circuits for extracting the encoded horizontal and vertical sync signals and the mode signal from an analog video signal;

FIG. **12**A is a circuit diagram of an onscreen programming circuit that produces video displays on the workstation's monitor according to yet another aspect of the present invention; and

FIG. **12**B is a circuit diagram of a circuit that inverts the polarity of horizontal and vertical sync signals that is used within the onscreen programming circuit of FIG. **12**A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention is a computerized switching system for allowing a number of computer workstations to be coupled to a number of remotely-located server computers. In

the presently preferred embodiment of the invention, up to thirty-two workstations can be connected to any of thirty-two remote computer systems. However, those skilled in the art will recognize that the number of possible interconnections can easily be modified for the environment in which the invention is to be used.

Referring now to FIG. **1**, the computerized switching system or crosspoint switch according to the present invention allows a number of server computers **52**, **54**, **56** to be coupled to a number of workstations **62**, **64**, **66**. Each workstation includes a video monitor **63**, a keyboard **65** and a cursor control device such as a mouse **67**. In accordance with the present invention, signals from the keyboard **65** and the mouse **67** are received by a signal conditioning circuit or pod **70**. The pod transmits the keyboard and mouse signals over a communication link **72** to a central crosspoint switch **60**. After being routed through the crosspoint switch **60**, the keyboard and mouse signals are retransmitted on another communication link **74** to a pod **76**, which is coupled to the remotely-located server computer. The pod **76** supplies the keyboard and mouse signals through appropriate connectors to keyboard and mouse input ports of the remote computer, just as if the keyboard **65** and mouse **67** were directly coupled to the keyboard and mouse input ports.

Audio and video signals produced by the remote server computer **52**, **54** or **56** are received by the associated pod **76** and transmitted in the reverse direction along the communication link **74** to the central crosspoint switch **60**. The central crosspoint switch routes the audio and video signals to one of the communication links **72** for transmission to a pod **70**. The pod **70** then supplies the audio and video signals to the associated video monitor **63** and a speaker **69** of the workstation. From a user's perspective, the work station appears as if it is directly coupled to the remote server computer.

FIG. **2** is a block diagram of a pod **70**. As described above, the pod operates to receive the mouse and keyboard signals and to transmit them through the crosspoint switch to a remotely-located server computer system. In addition, the pod receives video and audio signals from the remote server computer by way of the central crosspoint switch and supplies them to the video monitor and speaker of the workstation.

The pod **70** generally comprises a central processing unit (CPU) **80** having its own random access and read only memories. A keyboard/mouse interface **82** is coupled to the CPU **80** to receive and condition the electronic signals from the keyboard **65** and mouse **67**. As the user moves the mouse or types on the keyboard, the keyboard/mouse interface **82** generates an interrupt signal that is fed to the CPU **80**. The CPU **80** then reads the digitally buffered keyboard and mouse signals from the keyboard/mouse interface **82** and converts the signals into a data packet that is transmitted to the remote computer.

As shown in FIG. **2**A, the pod to pod data packet **90** begins with a unique character **92** that marks the beginning of the data packet followed by a byte **94** that indicates the length of the packet. The next byte **96** identifies the type of data (mouse, keyboard, monitor type etc.) that the packet represents. The next series of bytes **98** represents the keyboard/mouse data to be transmitted to the server computer. Finally, a checksum byte **100** allows for the correction of errors that may occur during transmission.

It should be noted that the pod to pod packets are not limited to carrying keyboard and mouse data. The packets allow the pod at the work station to "talk to" the pod at the remote computers. Each pod acknowledges to the other that a packet was received correctly and in case of an error requests that a packet be retransmitted.

After the CPU **80** has assembled the pod to pod packet, the packet is transmitted to a quad UART **84**, which transmits and receives serial data on four leads **84***a*-**84***d*. The pod to pod packet is serialized and transmitted on the lead **84***a* to a differential line driver/receiver **88** that transmits and receives data on a number of twisted-pair cables **72***a*-**72***e*, that are coupled to the central crosspoint switch **60** (shown in FIG. **1**). In the presently preferred embodiment of the invention, the differential line drivers/receivers are model Nos. DS8921, manufactured by National Semiconductor. The drivers transmit a positive version of the data on one wire of the twisted-pair cable and the inverse of the data on the other wire of the twisted pair. This allows the data to be transmitted along cables up to 500 feet in length without the use of additional amplifiers.

As the user is operating the remote server computer, the remote computer may transmit commands which affect the operation of the mouse and keyboard. These include the mouse sensitivity, the keyboard repeat rate, activating one or more LEDs on the keyboard (such as the number lock, capital letter lock, etc.). The keyboard/mouse commands contained in a pod to pod packet transmitted from the remote computer are received on twisted-pair cable **72***b* by the differential line driver/receiver **88**. The UART **84** converts the received serial keyboard/mouse commands into a parallel format and supplies the data to the CPU **80**. The CPU **80** then generates the appropriate signals which are fed to the keyboard/mouse interface **82** and applied to the keyboard **62***b* and mouse **62***c*.

Video signals transmitted from the remote server computer are received on three sets of twisted-pair cables **72***f*, **72***g*, and **72***h* by a set of differential line receivers **90**. The output signals produced by the differential line receivers **90** are supplied to a video amplifier **92**. The output of the video amplifier is coupled to a sync extract circuit **94** which removes an embedded horizontal and vertical sync signal as well as a mode signal from the green, blue and red video signals respectively. The sync extract circuit **94** supplies the red, blue, and green analog video signals as well as the horizontal and vertical sync signals on separate leads to an onscreen programming circuit **99** that is described in further detail below. The onscreen programming circuit **99** feeds the video signals to a connector **96**, which is coupled to the video monitor of the workstation by a conventional video cable **97**. As will be described in further detail below, the horizontal and vertical sync signals are embedded into the green and blue color video signals in order to minimize the number of wires that extend between the workstation and the remote server computer as well as to reduce the complexity of the crosspoint switch.

The CPU **80** also reads a set of four monitor sense leads **95** to determine what type of monitor is connected to it. Monitor sense data is generated and transmitted in a pod to pod packet as shown in FIG. **2**A. The remote computer receives the monitor data and supplies it to the remote computer in order to adjust its video signals accordingly.

In addition to transmitting and receiving keyboard and mouse signals from the remote computer, the pod **70** can communicate with the central crosspoint switch. Data to be transmitted to the central crosspoint switch are sent on a twisted pair cable **72***c* while data transmitted from the central crosspoint switch are received on a twisted pair cable **72***d*.

Commands sent between the pod **70** and the central crosspoint switch allow a user to connect the work station to another remote computer, allow the central crosspoint switch to interrogate the status of the pod, update the firmware of the pod, etc. using the packet structure shown in FIG. **2**B as will be described below. When the user wishes to send a command

to the central crosspoint switch, a special sequence of keystrokes is used. In the present embodiment of the invention, all commands are preceded by the "printscreen" key and end with the "enter" key. The CPU **80** parses the keyboard strokes for these keys and analyzes the keystrokes to determine the destination of the command. If the command is directed to the pod itself, no data packet is produced. If the command is directed to the remote computer, a pod to pod packet is generated and transmitted. If the command is directed to the central crosspoint switch, the CPU assembles a command packet that is transmitted to the central crosspoint switch on the twisted pair cable **72***c*.

A block diagram of a pod **76** that is coupled to the remote server computers is shown in FIG. **3**. The pod **76** includes a central processing unit (CPU) **120** that is coupled to a keyboard/mouse interface **134**. The keyboard/mouse interface **134** supplies signals to and receives signals from the server computer's keyboard and mouse connectors. The keyboard and mouse signals from the computer's keyboard and mouse connectors are read by the CPU **120** and assembled into a pod to pod packet in the same manner as the pod to pod packet described above and shown in FIG. **2**A. The pod to pod packet produced by the CPU **120** is delivered to a QUAD UART **136** that transmits the packet serially over a lead **136***b* to a differential line driver **140**. The differential line driver drives a twisted-pair cable **74***a* that is coupled to the central crosspoint switch.

A pod to pod packet that is transmitted from a workstation is received on a twisted-pair cable **74***b* and supplied to differential line receiver **140**. The output signal of the differential line receiver is supplied to the QUAD UART **136** which converts the packet from a serial format to a parallel format. The CPU reads the packet and then transmits the received keyboard and mouse signals to the keyboard and mouse interface **134** where the signals are supplied to the remote computer's keyboard and mouse connectors in the same manner as if the keyboard and mouse were directly connected to the remote server computer. The particular format of the signals applied to the keyboard and mouse connectors may vary with the type of the remote computer. The CPU within the pod **76** is therefore programmed to translate the signals into their proper format.

Commands sent from the pod **76** to the central crosspoint switch allow the remote computer to interrogate the status of the pod, update the firmware of the pod etc. using the packet structure of FIG. **2**B. As with the user pod, all commands are preceded with the "printscreen" key and end with the "enter" key. The CPU **120** parses the keyboard strokes for these keys and analyzes the keystrokes to determine the destination of the command. If the command is directed to the pod **76**, no data packet is produced. If the command is directed to the workstation, a pod to pod packet is generated and transmitted. If the command is directed to the central crosspoint switch, the CPU assembles a command packet that is transmitted to the central crosspoint switch on a twisted pair cable **74***d*.

The signals from the remote computer's video port are supplied through a video cable **143** to a connector **144**. As will be described below, the red, green and blue analog video signals along with the horizontal and vertical sync signals are supplied to a sync combine circuit **146** that encodes the horizontal and vertical sync signals onto the green and blue analog video signals respectively. The current mode of the monitor (i.e., the correct polarity of the horizontal and vertical sync pulses) is encoded by the sync combine circuit **146** onto the red analog video signal. The output of the sync combine is supplied to an amplifier **148** that conditions the signals and supplies the video signal to three differential line drivers **140** that transmit the signals over three separate twisted-pair cables **74***f*, **74***g*, and **74***h* to the central crosspoint switch.

The monitor sense data received from a remote workstation is decoded by the CPU **120** and supplied to a set of monitor sense leads **147**. The remote computer receives the monitor sense data on these leads and adjusts its video signals for the particular monitor that is displaying the video signals.

The audio signals produced by the remote computer are supplied to a differential line driver **140** and are transmitted over a twisted-pair cable **74***c* to the central crosspoint switch.

FIG. **4** is a block diagram of the central crosspoint switch. The central switch **60** includes a master central processing unit (CPU) **150**, a number of input cards **152**, a number of switch cards **154** and a number of output cards **156**. Each of the input cards transmits signals to and receives signals from up to eight of the remotely located server computers while each of the output cards transmits to and receives signals from up to eight of the remotely located workstations. The master CPU **150** is coupled to each of the input cards **152**, the switch cards **154** and each of the output cards **156** by a digital bus **158**. Together the master CPU, input cards, switch cards and output cards are connected via a local area network.

Pod to pod packets are routed from an input card through the switch card to an output card and vice versa on a digital backplane **160**. The analog video and audio signals are transmitted between the input cards, the switch card **154** and the output cards **156** on a separate analog backplane **162**.

A block diagram of an input card **152** is shown in FIG. **5**. The output cards **156** are identical to the input cards except that the direction of the audio/video signals is reversed and therefore will not be discussed separately. The input card **152** includes its own CPU **170** that transmits and receives data from the master CPU **150**. Signals transmitted from the remote server computer are received by a set of differential line drivers/receivers **172***a-b*. Commands sent from the remote computer to the central crosspoint switch are received by an octal UART **173** where the commands are converted from a serial to a parallel format. The UART feeds the commands to the CPU **170** where they are interpreted and forwarded to the master CPU **150**.

To transmit data between the input, output and switch cards of the crosspoint switch, the data is packetized in the format shown in FIG. **2**B by the CPU of the card sending the packet. A packet begins with a unique character **112** that marks the beginning of the packet. A destination address **114** follows the start character. The address uniquely identifies one of the cards in the crosspoint switch. A byte **116** indicates the size of the packet while a byte **118** indicates the type of data included in the packet. A series of bytes **120** are the data to be transmitted from one card to another. Following the data, a byte **122** indicates the sending card's unique address. A checksum byte **124** follows the sender's address and a unique character **126** is sent as a trailer. The transmission of all data packets between the cards of the crosspoint switch is controlled by the master CPU **150**.

Returning to FIG. **5**, commands generated by the CPU **170** to be transmitted to the pod that is coupled to a remote server computer are transmitted on a lead **174***b* to a differential line driver **172**. Pod to pod packets received from the central computer are routed through the input card on a lead **174***c* to the digital backplane **160**. Similarly, pod to pod packets transmitted from the remote workstation are received from the digital backplane, routed through the input card on a lead **174***d* and supplied to the differential line driver **172***a*.

In order to shield the video signals from the noise on the digital backplane, the video and audio signals transmitted from the remotely located server computer are routed on a

separate analog backplane **162**. The audio signals received from the remote computer are routed through the input card on a lead **174***e* and applied to the analog backplane **162**. Video signals are received by the differential line receivers **172***a* and routed through the input card on leads **174***f-h* to the analog backplane.

In the present embodiment of the invention, each input card includes up to eight sets of differential line drivers/receivers **172***a*-**172***f* (the remaining six driver/receivers not shown) to receive signals from up to eight remotely located server computers. The signals from each remotely located computer are routed through the input card to the digital and analog backplanes in the manner described above.

FIG. **6** is a block diagram of a switch card **154**. The switch card includes its own central processing unit (CPU) **180**. The CPU **180** transmits and receives signals from the master CPU **150** in order to control the position of a 16×16 digital crosspoint switch **182** and a 16×16 analog crosspoint switch **184** using a set of control leads **183**. The digital crosspoint switch **182** connects the keyboard/mouse signals transmitted between a workstation and a remote server computer as well as audio signals generated by the remote server computer to the workstation. The analog crosspoint switch **184** transmits the video signals between a remote server computer and any of the workstations.

FIG. **7** shows how the digital backplane portion of the 32×32 crosspoint switch is configured using four switch cards **154***a*, **154***b*, **154***c* and **154***d* in order to transmit signals between 32 workstations and 32 remotely located server computers. The switch card **154***a* has sixteen input lines **186** that are coupled to sixteen remotely located server computers and sixteen output lines **188** that are coupled to sixteen workstations. The switch card **154***b* has sixteen input lines coupled to another sixteen remotely located server computers and sixteen output lines **194** that are coupled to each of the sixteen output lines **188** of the switch card **154***a*. The switch card **154***c* has sixteen input lines **198** that are coupled to the sixteen input lines **186** of the switch card **154***a*. The sixteen output lines **200** of the switch card **154***c* are coupled to another sixteen remotely located workstations. The switch card **154***d* has sixteen input lines **204** that are coupled to each of the sixteen input lines **192** of the switch card **154***b*. The sixteen output lines **206** of the switch card **154***d* are coupled to the sixteen output lines **200** of the switch card **154***c*. The analog backplane is constructed in a similar fashion as the digital backplane described above. As can be seen, the arrangement of the switch cards **154***a*, **154***b*, **154***c* and **154***d*, allows data from any one of thirty-two remotely located computers to be coupled to any one of thirty-two remotely located workstations.

A switching arrangement of the type shown in FIG. **7** is required for each signal that is to be transmitted between the remotely located server computer to a corresponding workstation. In the present embodiment of the invention, each workstation sends and receives pod to pod packets as well as receives audio and video signals from the remote computer. Therefore, for the 32×32 digital switch shown in FIG. **6**, the digital backplane includes two sets of switches of the type shown in FIG. **7** and the analog backplane includes another four sets of switches for the video and audio signals.

In the presently preferred embodiment of the invention, the digital 16×16 switches **182** are implemented using a pair of 16×8 digital switches as shown in FIG. **8**. Each 16×16 switch comprises switches **210** and **216**. The switch **210** has sixteen input lines **212** and eight output lines **214**. The switch **216** has sixteen input lines **218** that are coupled to each of the input lines **212**, and eight output lines **220**. In the presently preferred embodiment of the invention, each of the 16×8 switches **210** and **216** are part numbers CD22M3494SQ, manufactured by Harris.

The analog backplane on which the video signals are transmitted is configured in the same fashion as the switch shown in FIG. **7**. However, because of the greater bandwidth required, each 16×16 switch **184** is implemented using eight 8×4 analog switches model no. DG884DN, manufactured by Siliconix. As can be seen in FIG. **9**, a 16×16 analog switch is implemented using switches **222**, **224**, **226** and **228** each having eight input lines and four output lines. The input lines of switches **222**, **224**, **226** and **228** are connected in parallel. A second set of switches **230**, **232**, **234** and **236**, each having eight input lines and four output lines. The input lines of switches **230**, **232**, **234** and **236** are connected in parallel. The outputs of switch **230** are coupled in parallel with the outputs of switch **222**, and the outputs of switch **232** are coupled in parallel with the outputs of switch **224**. The outputs of switch **234** are coupled in parallel with the outputs of switch **226** and the outputs of switch **236** are coupled in parallel with the outputs of switch **228**.

To minimize the number of wires that must extend from the remote computer to the workstation, the present invention encodes the horizontal and vertical sync signals onto the analog color video signals transmitted from the remote computer. FIGS. **10**A-**10**C show the details of the sync combine circuit **146** (FIG. **3**) that encodes the vertical and horizontal sync signals as well as the mode signal of the monitor. FIG. **10**A shows a circuit that encodes the horizontal sync signal onto the green video signal produced by a remote computer. The circuit includes an exclusive or (XOR) gate **250** having a first input that receives the horizontal sync signal produced by the computer system. A resistor **252** and capacitor **254** are connected in a series between the first input of the XOR gate and ground. At the junction of the resistor **252** and the capacitor **254** are two series connected inverting gates **256** and **258**. The output of the inverter **258** is supplied to a second input of the XOR gate **250**.

The XOR gate **250** operates to encode the horizontal signal as a positively going pulse no matter what the normal state of the horizontal sync signal is. The voltage on the capacitor **254** is equal to the average valve of the horizontal sync signal. The output of the inverting gate **258** has a logic level equal to the non-active state of the horizontal sync signal. The output of the XOR gate **250** is coupled to an inverting input of an amplifier circuit **260**. The non-inverting input of the amplifier **260** is connected to receive the green analog video signal. When the horizontal sync signal is in its normal state, the output of the amplifier **260** follows the green analog video signal. However, when the horizontal sync signal is activated, the active video is at zero volts and the amplifier **260** produces a negative going horizontal sync pulse.

FIG. **10**B shows a circuit that encodes the vertical sync signal onto the blue analog video signal produced by the remote computer. The circuit comprises an exclusive or (XOR) gate **270**, a resistor **272**, capacitor **274** and a pair of inverters **276**, **278** that are connected in the same way as the horizontal sync circuit shown in FIG. **10**A and described above. The output of the XOR gate is always a positive going pulse when the vertical sync signal is activated. The output of the XOR gate is fed to the inverting input of an amplifier **280**. When the vertical signal is in its normal state, the output of the amplifier **280** follows the blue analog video signal. However, when the vertical sync signal is activated, a negative going pulse, V-sync, is created by the amplifier.

FIG. **10**C is an electronic circuit that encodes the mode of the video monitor. The mode refers to the polarity of the

horizontal and vertical sync signals. Changes in the mode affect the size of the video display produced by a video monitor. To encode the mode of the video signal, the circuit shown in FIG. **10**C is used. The circuit comprises two AND gates **284** and **286**. The AND gate **284** has one input coupled to the output of the inverter **258** (shown in FIG. **10**A). The AND gate **286** has one input coupled to the output of the inverter **278** (shown in FIG. **10**B). The remaining inputs of the AND gates **284** and **286** are coupled to the output of the XOR gate **270** (shown in FIG. **10**B) so that the mode signal is only encoded onto the red video signal when the vertical sync signal is activated.

The output of the AND gates **284** and **286** are coupled in series with a pair of resistors **290** and **292**, respectively. The resistors **290** and **292** are coupled together at a common node **291**. Connected between the node **291** and ground is a resistor **293**. Each time the vertical sync signal is active, the AND gates **284** and **286** produce a voltage at the node **291** that is proportional to the mode of the video monitor. The proportional voltage is fed into the inverting input of an amplifier **294**. The non-inverting input of the amplifier **294** is connected to receive the red analog video signal produced by the remote computer. When the vertical sync signal is in its normal state, the output signal of the comparator **294** follows the red analog video signal. However, when the vertical synchronize signal is activated, the mode signal is encoded on the red video signal.

After the video signals have been transmitted from the remote server computer and through the analog crosspoint switch to the remote workstation, the sync signals are extracted from the green and blue video signals. To extract the horizontal sync signal from the green video signal, the circuit shown in FIG. **1**A is used. The green video signal is received by the pod at a differential receiver **90** that produces an output signal which is fed to a non-inverting input of a clipping amplifier **302**. The output signal of the amplifier **302** is the green analog video signal that is fed to the video monitor. A resistor **306** is disposed between a non-inverting input of a comparator **304** to the output of the differential receiver **90**. Connected between a non-inverting output of the comparator **304** and the non-inverting input is a feedback resistor **308**. An inverting input of comparator **304** is tied to a constant reference voltage that is supplied by the voltage divider defined by resistors **310** and **312**. When the output signal of the differential receiver **90** has a magnitude below the voltage provided at the inverting input of the comparator **304**, the inverting output of amplifier **304** creates a positive going pulse. The positive going pulse is supplied to an input of an exclusive or (XOR) gate **314**. Coupled to another input of the exclusive or gate **314** is the horizontal mode (H-mode) signal which is recovered from the red analog video signal as will be described below. The XOR gate **314** adjusts the polarity of the horizontal sync signal depending on the value of the H-mode signal.

The circuit required to extract the vertical sync signal from the blue video signal is the same as the circuit shown in FIG. **11**A except that the exclusive or (XOR) gate receives the V-mode signal in order to adjust the polarity of the vertical sync signal.

To recover the video mode signal, the present invention utilizes the circuit shown in FIG. **11**B. The red analog video signal is received at a pod by a differential line receiver **90** that produces the red analog video signal. The output of the differential line receiver **90** is coupled to the inverting inputs of a pair of comparators **320** and **324**. The comparators **324** are gated by the output of a one shot **326** that is triggered by the rising edge of the vertical sync pulse so that the comparators only change state when the vertical sync signal is active. The noninverting input of comparator **324** is supplied with a reference voltage produced by a voltage divider that comprises a resistor **326** and a resistor **328**. The inverting input of the comparator **320** is supplied with a constant voltage produced by a voltage divider that comprises a resistor **330** and a resistor **332**.

A resistor **334** is placed between the output of comparator **320** and the inverting input of comparator **324**. Finally, a resistor **336** is placed between the inverting input of comparator **320** and the inverting input of comparator **324**.

The mode extract circuit produces two signals, H-mode and V-mode, having logic levels that are dependent on the magnitude of the mode signal encoded on the red video signal. If the magnitude of the mode signal is between 0 and −0.15 volts, the H-mode signal will be low and the V-mode signal will be low. When the mode signal has a magnitude between −0.15 and −0.29 volts, the H-mode signal will be high and the V-mode signal will remain low. The V-mode signal is high and the H-mode signal is low when the magnitude of the mode signal is between −0.29 volts and −0.49 volts. Both the H-mode and V-mode signals are high when the magnitude of the mode signal is less than −0.49 volts. As will be appreciated, the values given above will differ if different circuit components are used.

Once the video mode signal has been decoded from the red video signal, the values of H-mode and V-mode are used to adjust the polarity of the horizontal and vertical sync signals using the XOR gate shown in FIG. **11**A.

As can be seen, the circuits shown in FIGS. **10**A-**10**C and **11**A, **11**B reduce the number of wires that must extend between the remote server computer and the workstation by encoding the sync and mode signals onto the color video signals at a time when the signals are normally unused.

Having now described the components of the present invention, its operation is described. To connect a workstation to a remote computer, a user sends a command that causes the central crosspoint switch to couple the keyboard/mouse signals to one of the remote computers. As indicated above, commands that affect the operation of the crosspoint switch as inserted between "printscreen" and "enter" keystrokes. The pod connected to the workstation detects these keys and transmits a packet to the CPU on one of the output cards. The CPU then transmits the packet to the master CPU that validates the request and issues a command to the switch cards to set the position of the 16×16 digital and analog switches **182** and **184** (FIG. **6**). Once the position of the switches has been set, the master CPU tells the computer pod **76** that the connection has occurred. The keyboard/mouse signals are then packetized and transmitted as pod to pod packets through the crosspoint switch. Video and audio signals from the remote computer are transmitted from the remote computer to the workstation.

As indicated above, the present invention provides the capability of allowing a user to send commands from a workstation to the central crosspoint switch in response to prompts that are displayed on the video monitor. The onscreen programming circuit **99** shown in FIG. **2** produces video signals that displays a menu of commands to be selected by the user. FIG. **12**A is a circuit diagram of the onscreen programming circuit **99**. The circuit includes a set of tri-state buffers **352**, **354** and **356** that have their inputs connected to the red, green and blue video signals provided by the sync extract circuit **94** (shown in FIG. **2**). When the tri-state buffers are energized, the red, green and blue video signals are passed to the video monitor. When the tri-state buffers **352**, **354** and **356** are in

their high impedance state, the video signals are produced by an onscreen programming circuit **364**, as will be described.

The onscreen programming circuit **99** produces its own horizontal and vertical sync signals using a sync generator **358**. The horizontal and vertical sync signals produced are supplied to a switch **360** that selects either the sync signals produced by the internal sync generator **358** or the external horizontal and vertical sync signals recovered from the green and blue video signals transmitted from the remote computer. The switch **360** receives a signal on a lead **361** that is coupled to the CPU **80** (FIG. **2**) that determines which set of horizontal and vertical sync signals are selected. The horizontal and vertical sync signals selected by the switch **360** are fed to the video monitor at the user's workstation. Also connected to the output of the switch **360** is a sync polarizer **362** that forces the polarity of the horizontal and vertical sync signals selected to be active low. The details of the sync polarizer **362** are shown in FIG. **12**B.

The sync polarizer includes a pair of exclusive OR (XOR) gates **400** and **402**. The XOR gate **400** has one input connected directly to the sync signal to be polarized. A resistor **404** is connected between the sync signal and the other input of the XOR gate **400**. Connected between the second input of the XOR gate **400** and ground is a capacitor **406**. The voltage on the capacitor **406** is the average voltage of the sync signals. The output of the XOR gate **400** feeds an input of the XOR gate **402**. The other input of the XOR gate **402** is coupled to a logic high signal. The output of the XOR gate **402** will be a negative going pulse each time the sync signal is activated no matter what the normal state of the sync signal is.

The outputs of the sync polarizer **362** are coupled to a horizontal and vertical sync input of an onscreen processor **364**. The onscreen processor produces red, green and blue video signals that display one or more alphanumeric characters that are programmed in its internal video ROM memory. To dictate which characters are placed on the video screen, the CPU **80** generates serial I^2C interface signals on a pair of leads **363** and **365**. These signals are applied to the onscreen processor **364** which causes the processor to retrieve from an internal video RAM characters that are to be displayed on the video screen. The onscreen processor **364** provides two signals HBFK and HTONE that are supplied to an overlay control logic circuit **366**. Also supplied to the overlay control logic circuit are four signals from the CPU **80** of the user pod. These four signals are H Tone Enable, OSD Enable, System Video Enable and Transparent. The overlay control logic circuit **366** reads the value of these logic signals and either enables or disables a set of tri-state buffers **368**, **370** and **372** on the tri-state buffers **352**, **354** and **356**. These tri-state buffers **368**, **370** and **372** couple the outputs of the onscreen processor **364** to the leads that connect to the monitor's color inputs.

When the tri-state buffers **352**, **354** and **356** are in their high impedance state, and the tri-state buffers **368**, **370** and **372** are active, then the video screen will only display those signals produced by the onscreen processor. Conversely, if the tri-state buffers **368**, **370** and **372** are in their high impedance state and the tri-state buffers **352**, **354** and **356** are active then the monitor displays the video signals produced by the remote computer system. If both sets of tri-state buffers **368**, **370**, **372** and **352**, **354** and **356** are both active, then the monitor will display the video signals produced by both the onscreen processor and the remote computer system. The following is a table that defines the logic of the overlay control logic circuit **366**.

HTONE	HBFK	H TONE ENABLE	OSD ENABLE	SYS_VID_EN	TRANS-PARENT	DISPLAY
X	0	X	0	0	X	screen blank
X	X	X	0	1	X	system video displayed only
X	1	0	1	0	0	OSD displayed only
1	1	1	1	0	0	OSD with transparent characters, i.e., characters transparent, OSD windows solid
X	X	X	1	0	1	illegal state
0	1	0	1	1	0	active system video with solid OSD characters
1	1	1	1	1	0	active system video transparent OSD characters and solid OSD windows
1	1	0	1	1	1	active system video with opaque OSD characters and windows
1	1	1	1	1	1	active system video transparent OSD characters and opaque OSD windows

The construction of the overlay control logic circuit **366** given the above table is considered to be within the skill of an ordinary digital electronics engineer.

To activate the onscreen programming display, the user begins the escape sequence by pressing the "printscreen" key. The CPU within the user pod recognizes this key and produces a menu on the video screen. The user then selects one or more items from the menu by typing on the keyboard or moving the mouse. The CPU then interprets these mouse/keyboard inputs as commands that are to be transmitted to the central crosspoint switch. Once the user ends a command by activating the "enter" key, the CPU can generate one or more packets that are transmitted to the central crosspoint switch that enable the user to connect to a different computer, monitor the status of a different computer, etc.

As can be seen, the present invention allows a user to access any of thirty-two remotely located computers from a central workstation. The system operates apart from a network so that if the network fails, a user can still access each of the server computers. Furthermore, the pods act as translators between different keyboard/monitor types and different computers. Because all pod to pod packets have the same format, previously incompatible equipment can be easily coupled together.

While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention. For example, although the present invention is described with respect to connecting workstations to remotely located computers for the purposes of system administration, it will be appreciated that the invention also has further uses. For example, it may be desirable to locate expensive computer equipment away from relatively inexpensive terminals. Therefore, the present invention could be used in academic sessions where it is desirable to allow students to operate remotely located computers from one or more workstations. It is believed that the present invention has numerous applications where it is desirable to separate computing equipment from computer display and data input devices. Therefore, the scope of the invention is to be determined solely from the following claims.

The invention claimed is:

1. A switching system comprising:

computer-side connectors including (1) plural computer-side user input device connectors for separately electrically connecting to respective user-input device inputs of plural computers and (2) plural computer-side video connectors for separately electrically connecting to analog video outputs of the plural computers, wherein the plural computer-side user input device connectors are electrically separate from the plural computer-side video connectors;

a first set of user-side connectors including (1) a first user-side user-input device connector for electrically connecting to a first user-input device and (2) a first user-side video connector for electrically connecting to an analog video input of a first monitor, wherein the first user-side user-input device connector is electrically separate from the analog video input of the first monitor;

a first analog video receiving circuit interposed between the computer-side connectors and the first set of user-side connectors for receiving analog video signals from one of the plural computers through at least one of the computer-side connectors; and

a first analog video processing circuit, interposed between the computer-side connectors and the first set of user-side connectors, for selecting, for at least one sub-region of an image to be displayed on the first monitor, at least one of (1) a portion of the analog video signals received by the first analog video receiving circuit and (2) internally generated analog video signals, to form an output analog video signal that is output to the first monitor via the first user-side video connector.

2. The switching system as claimed in claim **1**, wherein the first analog video receiving circuit further comprises a synchronization signal detecting circuit for detecting one of a horizontal- and a vertical-synchronization signal corresponding to the analog video signals from the at least one of the plural computers through the at least one of the computer-side connectors.

3. The switching system as claimed in claim **1**, wherein the first user-input device comprises at least one of a computer mouse and a keyboard.

4. The switching system as claimed in claim **1**, wherein the first analog video processing circuit comprises a multiplexer for multiplexing (1) the portion of the analog video signals received by the first analog video receiving circuit and (2) the internally generated analog video signals without requiring a frame buffer.

5. The switching system as claimed in claim **1**, further comprising a user-input device translator, disposed between at least one of the plural computer-side user-input device connectors and the first user-side user-input device connector, for translating information from the first user-input device in a first format to a second format used by at least one of the plural computers.

6. The switching system as claimed in claim **1**, wherein the first analog video receiving circuit receives separate analog red, green and blue signals.

7. The switching system as claimed in claim **1**, further comprising:

digital switching circuits; and

analog switching circuits, wherein user-input device information is routed from at least one of the plural computer-side user-input device connectors to the first user-side user-input device connector on the digital switching circuits independent of the analog video signals that are routed from at least one of the computer-side video connectors to the first user-side video connector on the analog switching circuits.

8. The switching system as claimed in claim **1**, further comprising:

a second set of user-side connectors including (1) a second user-side user-input device connector for electrically connecting to a second user-input device and (2) a second user-side video connector for electrically connecting to an analog video input of a second monitor, wherein the second user-side user-input device connector is electrically separate from the analog video input of the second monitor;

a second analog video receiving circuit for receiving analog video signals from one of the plural computers through the computer-side connectors; and

a second analog video processing circuit for selecting, for at least one sub-region of an image to be displayed on the second monitor, at least one of (1) a portion of the analog video signals received by the second analog video receiving circuit and (2) internally generated analog video signals, to form an output analog video signal that is output to the second monitor via the second user-side video connector.

9. The switching system as claimed in claim **1**, further comprising:

a user-input device command detector, connected to the first user-side user-input device connector, configured to

detect a first command by which the first user-input device requests that the analog video signals of one of the plural computers be replaced by analog video signals of another of the plural computers and configured to send commands other than the first command from the first user-input device to one of the plural computers.

10. The switching system as claimed in claim **1**, further comprising:

a user-input device command detector, connected to the first user-side user-input device connector, configured to detect a first command by which the first user-input device requests that the analog video signals of one of the plural computers be replaced by analog video signals of another of the plural computers in response to the internally generated video signal that is output to the first monitor via the first user-side video connector, and said user-input device command detector configured to send commands other than the first command from the first user-input device to one of the plural computers.

11. The switching system as claimed in claim **1**, wherein a first computer-side user-input device connector and a first computer-side video connector of the plural computer-side connectors are contained within a first computer-side housing, and a second computer-side user-input device connector and a second computer-side video connector of the plural computer-side connectors are contained within a second computer-side housing.

12. The switching system as claimed in claim **1**, wherein said at least one of (1) the portion of the analog video signals received by the first analog video receiving circuit and (2) the internally generated analog video signals comprises only (1) the portion of the analog video signals received by the first analog video receiving circuit in a first mode of operation.

13. The switching system as claimed in claim **1**, wherein said at least one of (1) a portion of the analog video signals received by the first analog video receiving circuit and (2) internally generated analog video signals comprises only (2) the internally generated analog video signals in a second mode of operation.

14. The switching system as claimed in claim **1**, wherein said at least one of (1) the portion of the analog video signals received by the first analog video receiving circuit and (2) the internally generated analog video signals comprises both (1) the portion of the analog video signals received by the first analog video receiving circuit and (2) the internally generated analog video signals in a third mode of operation.

15. The switching system as claimed in claim **1**, wherein the internally generated analog video signals comprise a menu.

16. The switching system as claimed in claim **7**, wherein the analog switching circuits comprise a cross-point switch.

17. The switching system as claimed in claim **1**, further comprising:

computer-side audio connectors for receiving audio signals from audio ports of the plural computers, and wherein the first set of user-side connectors further comprises a user-side audio connector for receiving the audio signals from one of the computer-side audio connectors.

18. The switching system as claimed in claim **1**, further comprising:

a user-input device command detector, connected to the first user-side user-input device connector, configured to detect first and second inputs from the first user-input device and for controlling the first analog video processing circuit (1) to output to the first monitor via the first user-side video connector the internally generated analog video signals in response to the first input and (2) to stop outputting to the first monitor via the first user-side video connector the internally generated analog video signals in response to the second input.

19. The switching system as claimed in claim **18**, wherein the internally generated analog video signals comprise a menu for selecting which of the plural computers is to have its video output by the first analog video processing circuit.

20. The switching system as claimed in claim **1**, further comprising:

a user-input device command detector, connected to the first user-side user-input device connector, configured to detect first and second inputs from the first user-input device, wherein prior to detecting the first input the first user-side video connector outputs analog video corresponding to a first computer of the plural computers, and wherein the user-input device command detector controls the first analog video processing circuit (1) to output to the first monitor via the first user-side video connector the internally generated analog video signals in response to the first input, and (2) in response to the second input, to stop outputting to the first monitor via the first user-side video connector the internally generated analog video signals and to output via the first user-side video connector analog video corresponding to a second of the plural computers, wherein the internally generated analog video signals comprise a menu for selecting which of the plural computers is the second computer to have its analog video output by the first analog video processing circuit.

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